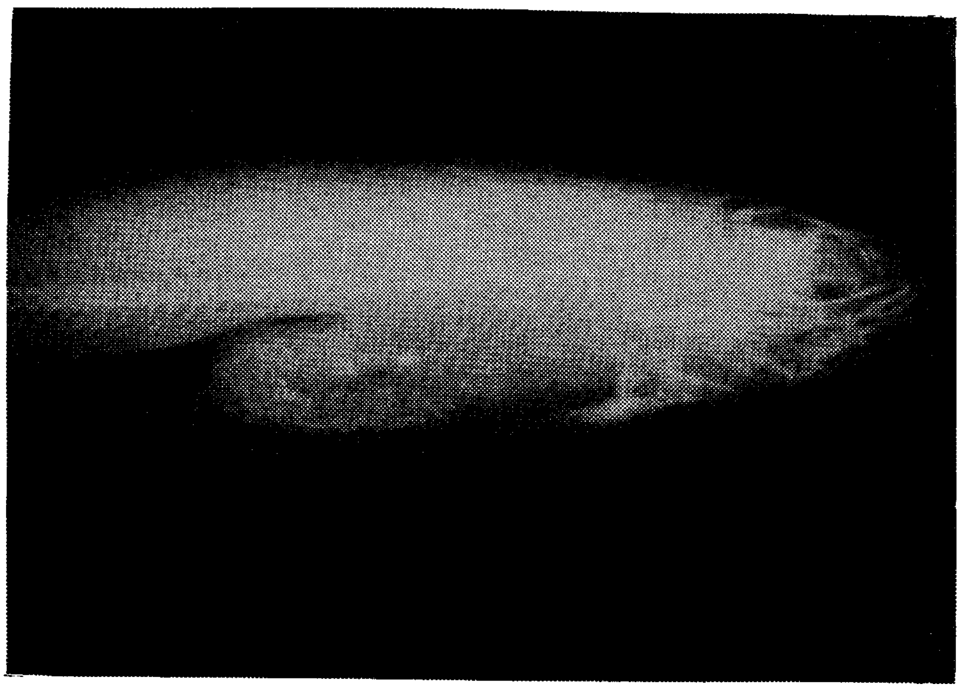
Volume 098
Article 03

FISHERY RESEARCH

Job Performance Report
Project F-73-R-15

WILD TROUT EVALUATIONS

Subproject II, Study IV



Job 1. Electrofishing Injury Investigations on the Big Wood River

by

Dan Schill
Principal Fisheries Research Biologist, IDFG

IDFG 94-29
October 1994

TABLE OF CONTENTS

Page

ABSTRACT 1

INTRODUCTION 2

OBJECTIVES 2

METHODS 3

RESULTS 4

DISCUSSION 4

RECOMMENDATIONS 7

ACKNOWLEDGMENTS 8

REFERENCES 9

LIST OF TABLES

Figure 1. Length-frequency of Big Wood River rainbow trout examined for electrofishing injury via X-rays 5

JOB PERFORMANCE REPORT

State of: **Idaho**

Project: **F-73-R-15**

Subproject: **II**

Study: **IV**

Name: **Wild Trout Evaluations**

Title: **Electrofishing ___ Iniury Investigations on the Big Wood River**

Job: **1**

Period Covered: **Aril 1. 1992 to March 31. 1993**

ABSTRACT

A number of recent studies suggest that electrofishing injuries commonly occur with methods and equipment used by biologists today. In this study, I document the incidence of electrofishing injury in an Idaho stream using typical in-state sampling methods and provide short-term guidelines for minimizing electrofishing injuries. I sampled fish during a single day of electrofishing on the Big Wood River in Southcentral Idaho. The crew sampled fish with straight direct current (DC) at 275-375 volts while drawing about 5 amps with two positive mobile probes. A subjective rating scheme measured both spinal injury and internal hemorrhaging from electrofishing. Only 4% of a 50 fish sample had detectable spinal damage; these were relatively mild vertebral compressions. Hemorrhaging was detected in four fish or 8% of the sample. This data is consistent with the literature which suggests that electrofishing with straight DC current will minimize injury rates. If pulsed current is needed for adequate galvanotaxic response, the frequency should be kept as low as possible to minimize injuries. This study and others do not address the possible effects of electrofishing at the population level. Research addressing the potential for population impacts is recommended.

Author:

Dan Schill
Principal Fisheries Research Biologist

INTRODUCTION

Electrofishing, as we know it today, originated in eastern Germany in the early 1930's (Hartley 1990). Haskell (1940) first employed the technique in the United States. Prototype electroshockers consisted of two electrodes wired to an AC generator, sometimes with a device permitting voltage variation. A post-war boom in electronics aided the development of alternative, portable types of current including DC and pulsed DC. Electrofishing quickly became a popular sampling technique for a variety of species in numerous countries.

Early biologists recognized the potential for fish injuries to occur and conducted a number of injury studies. An Idaho study examining effects of AC electrofishing on large rainbow trout Oncorhynchus mykiss demonstrated that fractured vertebrae and broken blood vessels are common (Hauck 1947). A later study, however, (Maxfield et al. 1971) reported no effects of Pulsed DC electrofishing on survival, growth, and fecundity of hatchery rainbow trout or their offspring. Based on results of these and other studies (e.g. Pratt 1954; Elliot 1972), many biologists came to believe DC current does not injure substantial numbers of fish.

More recent studies suggest, however, that injuries do commonly occur with power levels and equipment currently used. Injuries are usually classified as either spinal damage (cracked, broken, or compressed vertebrae) or hemorrhages visible in the muscle wall in the vicinity of the spine. Sharber and Carothers (1990) reported spinal injury rates of about 50% when pulsed DC was used to collect large rainbow trout. Fredenberg (1992) demonstrated that 60-98% and 44-62% of rainbow trout and brown trout, respectively, suffered spinal and/or hemorrhage injuries following pulsed DC electrofishing in field situations. Additional studies (Hollander and Carline 1992; Meyer and Miller 1991) agree with these results. Pulsing direct current appears to increase injury rates markedly (Lemarque 1990).

While the above studies suggest pulsed DC injury rates are greater than previously thought, little is known about the long-term effects of these injuries on fish survival. Nonetheless, a moratorium on sampling in nearly all Alaska streams containing rainbow trout has been in effect since 1990 (Holmes et al. 1990). Without additional study, future restriction of electrofishing activities seems possible because of negative public opinion (J. Reynolds, University of Alaska, personal communication).

OBJECTIVES

1. Estimate injury rates from a typical electrofishing operation in a typical Idaho stream.

2. Review existing electrofishing injury studies and provide guidelines for electrofishing in Idaho waters.

METHODS

I assessed electrofishing injury in the Big Wood River from collections made for population estimation and genetics work during August 1991. I sampled fish during a single day of electrofishing conducted by Magic Valley Region personnel for a regulation evaluation. Sampling gear consisted of a Coffelt VVP15 powered by a Honda 5000 watt generator, both mounted in a 14 ft canoe. The crew sampled fish with straight Direct Current (DC) at 275-375 volts while drawing about 5 amps with two positive mobile probes.

Magic Valley Region personnel used sampling techniques typical for medium-sized streams in Idaho. The crew waded downstream, towing the canoe and using both positive electrodes to cover the channel. Setters collected fish as soon as possible, attempting to minimize their field exposure time and proximity to electrodes. Using random numbers, I randomly selected 50 fish during measuring procedures but did not inform the netting crew of the chosen numbers until designated fish were in hand.

Samples were immediately frozen on dry ice. One year later, fish were defrosted and X-rayed at a local medical laboratory using standard medical film. Film was exposed for 1/30th of a second at 50 milli-amps and 48-50 kvolts. X-rays were examined with a magnifying lens to observe spinal damage. I counted vertebrae from the anterior portion of the spinal column to any injury sites and recorded that number. A rating scheme, developed by Fredenburg (1992) and Reynolds (unpublished 1990 manuscript), was used to characterize the degree of spinal injury. The scale is as follows:

- 0 - no spinal damage apparent
- 1 - compression of vertebrae only
- 2 - misalignment of vertebrae, which may include compression
- 3 - fracture of one or more vertebrae or complete separation of two or more vertebrae.

Autopsies were subsequently conducted to determine the extent of hemorrhaging. I filleted both sides with an electric knife, cutting as close to the spine as possible. I visually examined both fillets for signs of hemorrhage and re-examined x-rays at that time. The degree of tissue injury was ranked on the following basis (Fredenburg 1992 and Reynolds - University of Alaska, unpublished 1990 manuscript):

- 0 - no hemorrhage apparent
- 1 - mild hemorrhage; one or more wounds in the muscle
- 2 - moderate hemorrhage; one or more small (< width of one vertebrae) wounds
- 3 - severe hemorrhage; one or more large (> width of one vertebrae) wounds on the spine.

RESULTS

I observed low levels of spinal damage when examining x-rays from Big Wood River fish. Only 4% of the sample (two fish) had detectable spinal damage. I classified both of these injuries as is due to vertebrae compression. Injury one involved vertebrae 32 and 33. Injury two involved vertebrae 14, 15, and 16.

The incidence of muscle tissue damage also appeared to be low for the Big Wood River sample. Hemorrhaging was observed in four fish or (8 percent) of the sample (n = 49). One specimen was too soft for dissection and was discarded. All four of the fish had class 1 hemorrhages and one individual also had a class 2 injury.

The 50 trout randomly selected for our study ranged from 123-426 mm and averaged 266 mm in total length (Figure 1). The two fish with vertebral damage were 205 and 220 mm long. Hemorrhages occurred in fish from 200 to 423 mm.

DISCUSSION

The above data has several important limitations. First, there was no control group collected with an alternate sampling technique to estimate background levels of spinal injury. Several authors (Hollender and Carline 1992; Sharber and Carothers 1990) have reported damaged vertebrae and hemorrhages in fish not collected via electrofishing. Some of the "injuries" I observed may be congenital abnormalities (Sharber and Carothers 1990). It is also possible that the fish examined had been electrofished previously and sustained damage before this study. The low estimate of injury makes potential overestimation of injuries in the Big Wood River moot, however.

Handling of the frozen fish may have compromised my ability to clearly observe hemorrhages. Several months before defrosting for the X-rays, fish were partially defrosted to permit unrelated genetic sampling and then refrozen. Thus, fish were at least partly defrosted twice before the autopsies. In some cases, blood dispersal in the tissue made it difficult to positively identify a hemorrhage. It is possible that additional hemorrhages in the musculature went undetected. In future work, autopsies should be performed within several months of sampling.

I had difficulty examining x-rays of fish less than 200 mm. The clarity of the exposures were marginal no matter what exposure times and power levels were used. Hollender (Pennsylvania Fish Commission, personal communication) recommends the use of a film designed for x-raying concrete for best results on small fish (Kodak Induxtrex AA or AX2). Unless specialized film is used, X-ray results of small fish should be viewed as minimum injury rates.

Given above study limitations, my results are consistent with the literature *which* suggests that DC electrofishing can be conducted with minimal injuries by not pulsing the current. Straight DC results in low injury rates (<10%) when compared to other types of current (Lemarque 1990; Fredenburg 1992). Pulsed DC

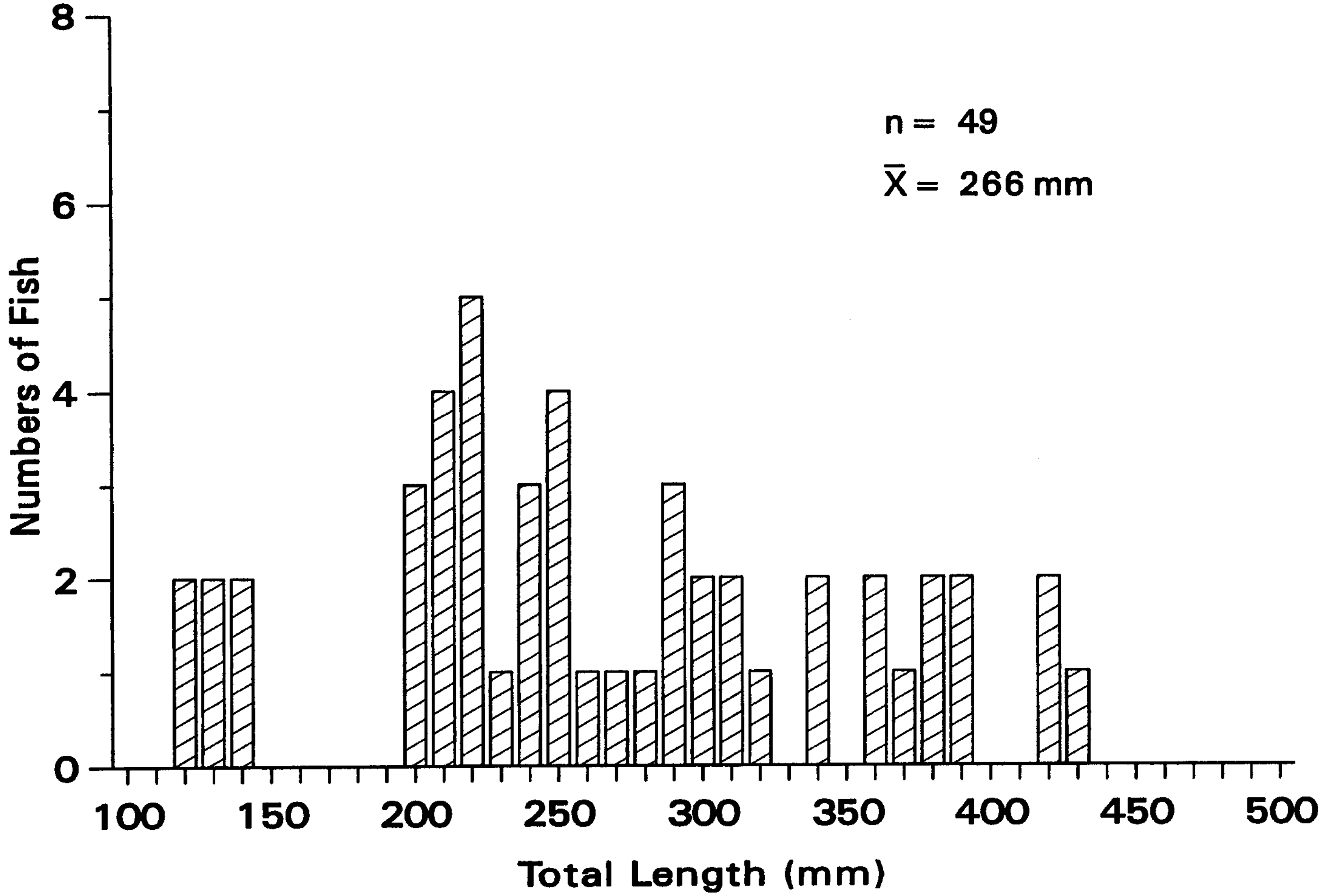


Figure 1. Length-frequency of Big Wood River rainbow trout examined for electrofishing injury via X-rays.

often results in injury rates in excess of 40% with 80-90% rates being reported (Fredenburg 1992; Sharber and Carothers 1990). Idaho Department of Fish Game personnel should use straight DC whenever galvanotaxic response is sufficient to achieve study objectives.

A general approach for minimizing electrofishing injuries would be to begin all sampling operations with straight DC at low to moderate voltages. If fish response is insufficient, a decision must be made to either increase the DC voltage or utilize pulsed DC current. Injury rates are positively correlated with pulse frequency (Pugh 1971; McMichael 1993). If pulsed DC is chosen, use the lowest possible frequencies (preferably <30 hz) that produce acceptable galvanotaxis.

Several manufacturers are currently building machines that produce specialized pulse trains designed to minimize fish injury. This type of machine should produce intermediate galvanotaxis between pulsed and straight DC (Norm Sharber, Coffelt Electronics, personal communication). There has been limited field testing of these products to date, however. When replacing worn out electrofishing units in the future, I recommend purchasing and equipment with straight DC, pulsed DC, and special pulsing features (e.g. CPM from Coffelt Manufacturing) to provide maximum flexibility. Such a combination is ordinarily not available but can typically be special-ordered at no extra cost.

The small sample size in our study precludes examination of the relationship between size and injury rates. There is conflicting evidence on the role of size on the frequency of injury. Several authors report no difference between size groups (Pratt 1954; Fredenburg 1992) but others report a positive relationship (McMichael et al. 1991). Hollender and Carline (1992) detected a 22% injury rate for small brook trout *Salvelinus fontinalis* (mean TL = 136 mm) so injuries are not limited to larger fish. In general, little attention has been paid to smaller fish below 300 mm in past studies, and films used have likely been insufficient for examining fish less than 200-250 mm.

The most important facet of electrofishing injury work remains completely uninvestigated. No studies have addressed the importance of electrofishing-caused deaths at the population level. They are lacking but have been called for (Hollender and Carline 1992; Holmes et al. 1990; Reynolds 1990). The few long-term studies undertaken indicate no long-term effects on survival or growth of individuals (Maxfield et al. 1971; Schneider 1992 and Roach 1992 as cited by Snyder 1992).

The latter three studies are an improvement over those simply documenting the percent of injuries occurring (including this report) but they still do not address the issue of population significance. For example, what proportion of a population residing in a 10 km stream would be injured or killed by sampling five 100 m reaches using typical density estimation methods? Such a level of sampling is probably typical of many management oriented surveys of small-medium sized streams. Assuming all fish in the five sample sites were exposed to current and died, a very unlikely worst case example, the population "exploitation" rate from sampling would only be 5%. What is the conditional natural mortality rate (Ricker 1958) for the stock being sampled and how do these rates interact with such, overexaggerated (100%) sampling losses? Assuming some level of natural mortality would have acted on the fish killed by shocking, the effects of such a sampling program would seem insignificant to stock status. Similarly, if growth or maturity rates were slowed for such small proportions of stocks the effects would likely be negligible. Under many conditions then, it seems the potential impacts of electrofishing would be unmeasurable, even if future long-term studies of mortality contradict the present evidence (Maxfield et al. 1971; Schneider 1992; Roach 1992) of no long-term effects for individuals.

Until population level data are collected, existing reports of electrofishing injury should be used with caution. Even the injury of individual fish with no demonstrated population effects may prove unacceptable to some members of the public. The banning of electrofishing in most of Alaska with virtually no supporting data is a case in point.

Even among the biological community there has been a tendency to emotionalize the issue. Despite the complete lack of population data discussed above, Snyder (1992) in his review, suggests the technique may have to be abandoned or severely limited in some waters "as an ethical responsibility to the fish, the populace we serve, and ourselves". Such anthropomorphism may result in severe, and perhaps, needless limitations being placed on what is arguably the profession's most effective sampling tool. We may have to simply accept that electrofishing causes the injury or death of more individual fish than we had previously believed. Other fish sampling methods result in a higher proportion of deaths (e.g. gillnetting) and is still deemed acceptable when population data is needed for research or management of fish stocks.

Fishery biologists need to develop well-designed injury studies to avoid the occurrence of irrational decisions about electrofishing in the future (Reynolds 1990). The studies should be designed to address impacts at the population level and not dwell on the percent of back injuries for a sample.

RECOMMENDATIONS

1. Begin electrofishing work in all Idaho waters with straight DC at low voltages. Increase DC voltages as necessary to ensure adequate galvanotaxic response. If captures remain unacceptable, utilize low pulse frequencies (e.g. 15 pps). If capture efficiencies do not improve at low pps use "injury-reducing" (e.g. Coffelt CPS) pulse trains if available.

2. Limit use of pulsed DC to frequencies less than 30 Hz unless necessary. Biologist using 60+ Hz should be aware they are injuring approximately 50% of sampled fish with unknown effects. The decision to proceed with such sampling should be based on the need for the data, the perceived strength or sensitivity of the population in question, and a rough guess about the proportion of the stock likely to be exposed to the electrical field.

3. Research targeted at examining effects of electrofishing injuries at the population level is needed. Such work does not appear to be forthcoming from other sources. Include smaller fish in injury work, adequate study has not been done on fish <400 mm in length.

ACKNOWLEDGMENTS

Dr. Steve Schneider kindly provided lab equipment and an x-ray technician. Jon Dudley assisted with the X-rays. Chip Corsi, Fred Partridge, and other Magic Valley Region personnel assisted with field sampling. Paul Kline assisted with autopsies and data analysis.

REFERENCES

Elliot, J.M. 1972. The effects of elctrofishing on the invertebrates of a lake district stream. Oecologia 9: 1-11.

Fredenburg, W. 1992. Evaluation of Electrofishing-induced Spinal Injuries Resulting From Field Electrofishing Surveys in Montana. Montana Department of Fish, Wildlife, and Parks, Helena, Montana. .43 pp.

Gatz, A.J., J.M. Loar, and G.F. Cada. 1986. Effects of repeated electroshocking on instantaneous growth of trout. North American Journal of Fisheries Management. 6:176-182.

Gatz, J.A., and S.M. Adams. 1987. Effects of repeated electroshocking on growth of bluegill X green sunfish hybrids. North American Journal of Fisheries Management 7:488-450.

Hartley, W.G. 1990. The History of Electric Fishing. In Cowx, I.G., and P. Lamarque ed. Fishing with electricity, applications in freshwater fisheries management. Blackwell Scientific Publications, Oxford.

Haskell, David C. 1940. An electrical method of collecting fish. Transactions of the American Fishery Society 69: 210-215.

Sauk, Forrest R. 1947. Some harmful effects of the electric shocker on large rainbow trout. Transactions of the American Fisheries Society 77:61-64.

Hollander, B., and R. Carline. 1990. Injury of Wild Brook Trout by Backpack Electrofishing. Paper presented at special electrofishing session, Western Division of the American Fishery Society annual meeting, July, Fort collins Colorado.

Holmes, R., D.N. McBride, T. Viavant, and J.B. Reynolds. 1990. Electrofishing induced mortality and injury to rainbow trout, arctic grayling,humpback whitefish, least cisco, and northern Pike. Fishery Manuscript No. 90-3. Alaska Department of Fish and Game, Anchorage, Alaska, 95 pgs.

Lemarque, P. 1990. Electrophysiology of Fish in Electric Fields. In Cowx, I.G., and P. Lamarque ed. Fishing with electricity, applications in freshwater fisheries management. Blackwell Scientific Publications, Oxford.

Maxfield, G.H., R.H. Lander, and R.L. Liscom. 1971. Survival, growth, and fecundity of hatchery-reared rainbow trout after exposure to pulsating direct current. Transactions of the American Fisheries Society 100(3): 546-552.

McMichael, G.A. 1993. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fishery Management. 13:229-233.

Meyer, C., and D. Miller. 1991. Spinal injury in trout electrofished with a coffelt VVP-15 or CPS(TM) system. Paper presented at annual meeting of Western Division of the American Fishery Society, Bozeman Montana, 15-19 July.

Pratt, V.S. 1954. Fish mortality caused by electrical shockers. Transactions of the American Fisheries Society 84:93-96.

Pugh, J.R. 1971. Effects of certain electrical parameters and water resistivities on mortality of fingerling silver salmon. U.S. Fish and Wildlife Service Fishery Bulletin NO. 208, 12 pp.

Reynolds, J.B. 1990. Electrofishing-induced injuries in fish: What we know and need to know. Unpublished manuscript. University of Alaska, Fairbanks.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations, Bulletin 191, Fisheries Research Board of Canada.

Roach, S.M. 1992. Injury and survival of northern pike captured by electrofishing. Master's thesis. University of Alaska, Fairbanks.

Sharber, N.G., and S.W. Carothers. 1990. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. In Cowx, I.G. ed., Developments in Electric Fishing. Proceedings of an International Sumposium on Fishing with Electricity, Hull, UK, 1988. Oxford: Fishing News Books Blackwell Scientific Publications.

Schneider, J. C. 1992. Field evaluations of 230-V AC electrofishing on mortality and growth of warmwater and coolwater fish. North American Journal of Fisheries Management 12:253-256.

Snyder, D.E. 1992. Impacts of electrofishing on fish. Larval Fish Laboratory, Colorado State University, Fort Collins, Colorado.

Submitted by:

Dan Schill
Principal Fisheries Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Chief
Bureau of Fisheries

Virgil K. Moore
Fisheries Research Manager

SIGNPAGE